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H04R 9/06 // H04R 1/24

(52) UK CL (Edition S)
H4J JAB JCA J30F

(56) Documents Cited
GB 0665815 A **EP 0624049 A2** **US 5802191 A**

(58) Field of Search
UK CL (Edition S) **H4J JAB JCA**
INT CL[7] **H04R 1/24 9/00 9/02 9/06**
Online: WPI, EPODOC, JAPIO

(54) Abstract Title
Coaxial loudspeaker with the magnetic circuit mounted in front of the diaphragm

(57) An inverted coaxial speaker 100 for use in automobile doors and similar thin structures has both its bass and tweeter components essentially located within the frustoconical outline of the bass speaker cone. A generally planar webbed structural member 104,204 extends across the larger end of the speaker cone, and centrally supports a magnetic structure 106,250 housing a coil for driving the speaker cone. A tweeter structure 132 is mounted on the magnetic structure and takes one of two forms. In a first form of the speaker, the magnetic structure has an axial channel 142 and the tweeter structure is mounted at the rear of the channel and sends sound through the channel; the tweeter has a conductive skirt 138 that is inductively coupled to the coil. In a second form of the speaker, the magnetic structure has no axial channel but does have a frontal depression 260 into which the tweeter structure is fitted; the tweeter structure has a tweeter voice coil 270 instead of being inductively-coupled. In both forms of the speaker, sound above about 4KHz leaves from a central region of the webbed structural member, and lower-frequency sound leaves from an annular region surrounding the central region.

FIG. 2

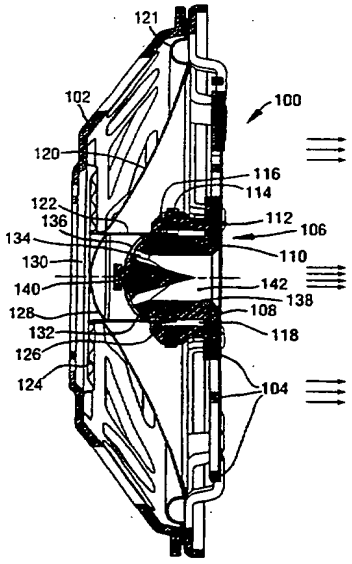
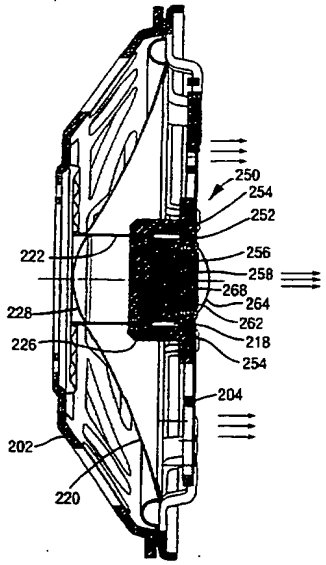


FIG. 3



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1

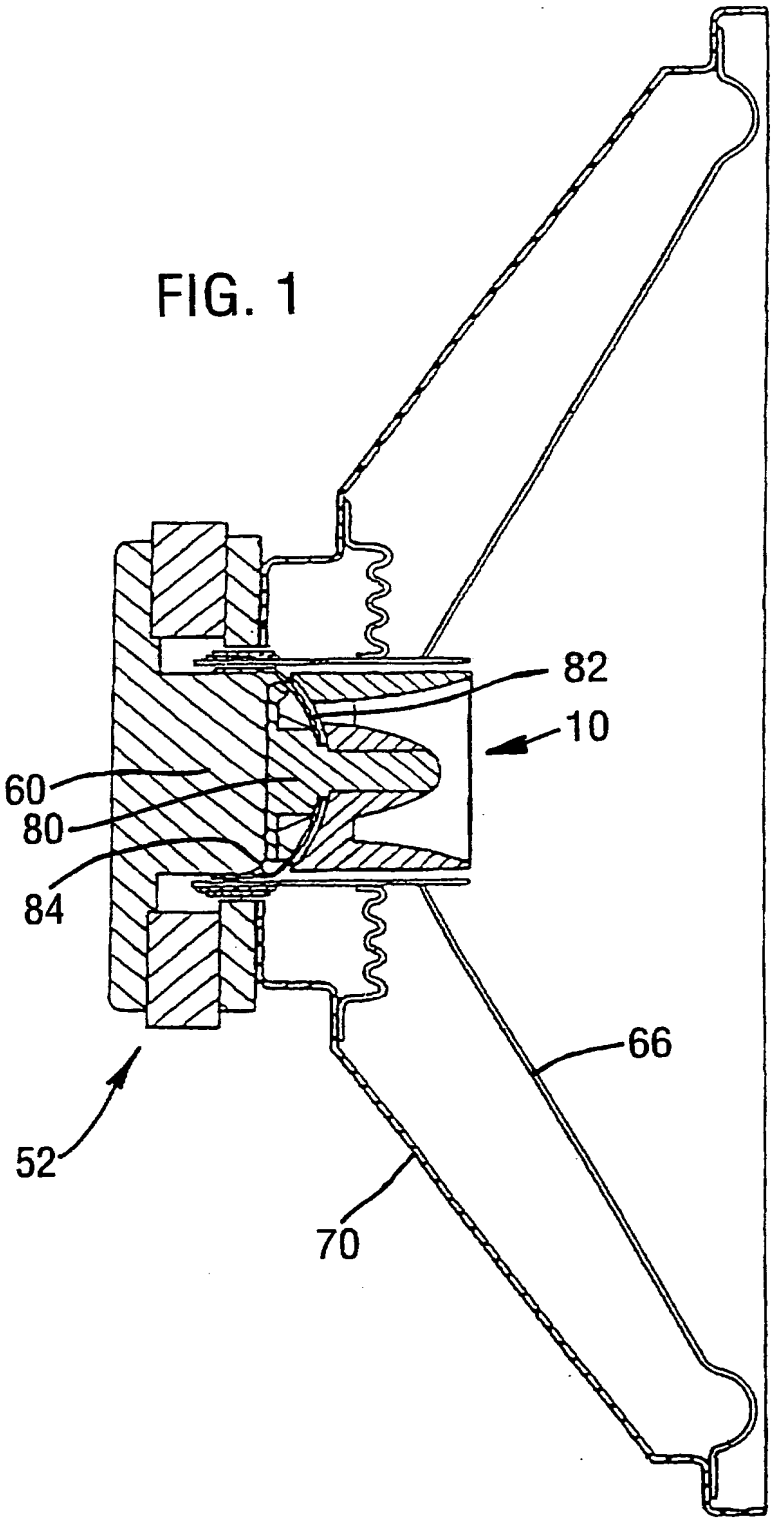
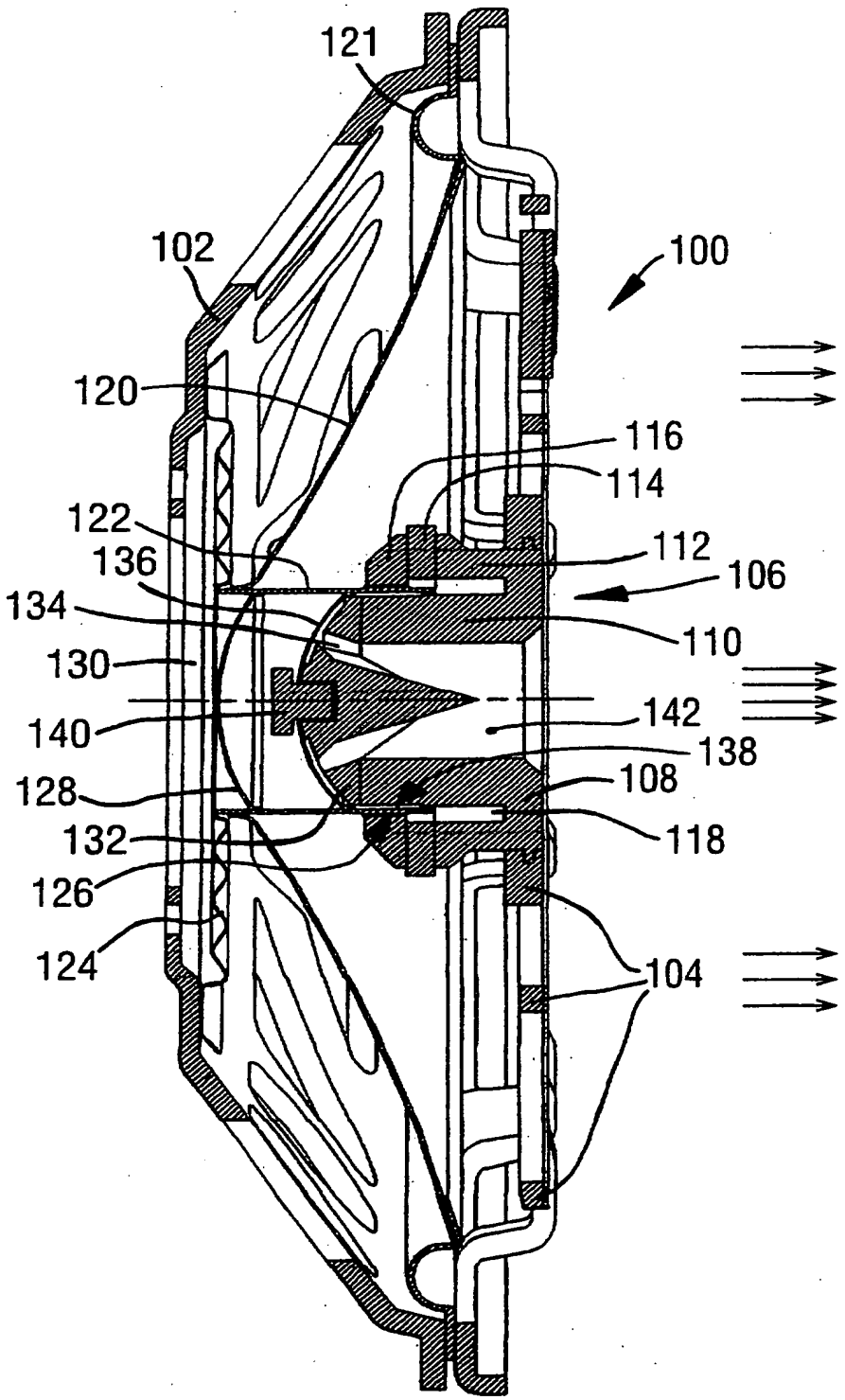


FIG. 2


121
102
100
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132
126
124
104

FIG. 3

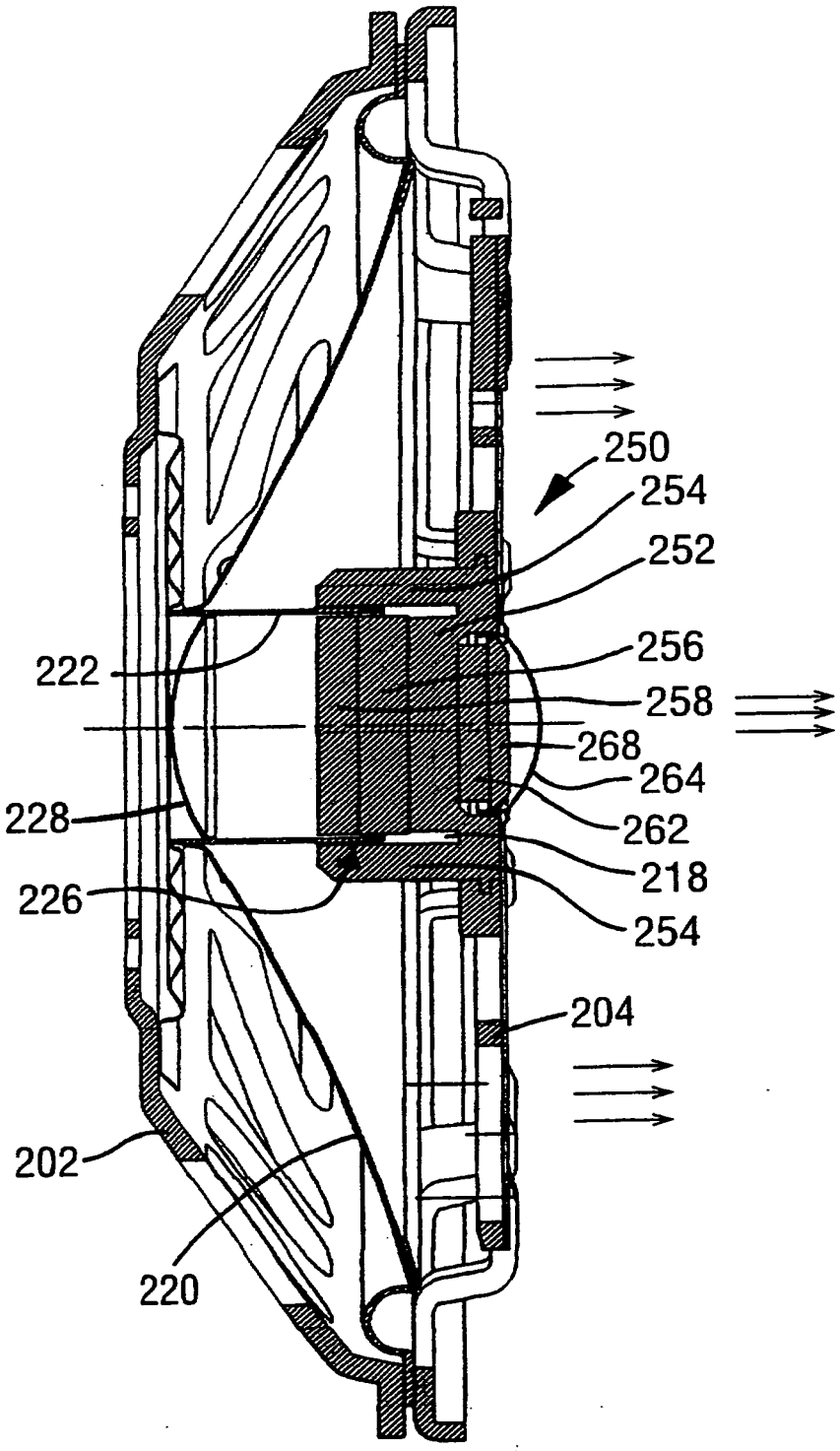


FIG. 4

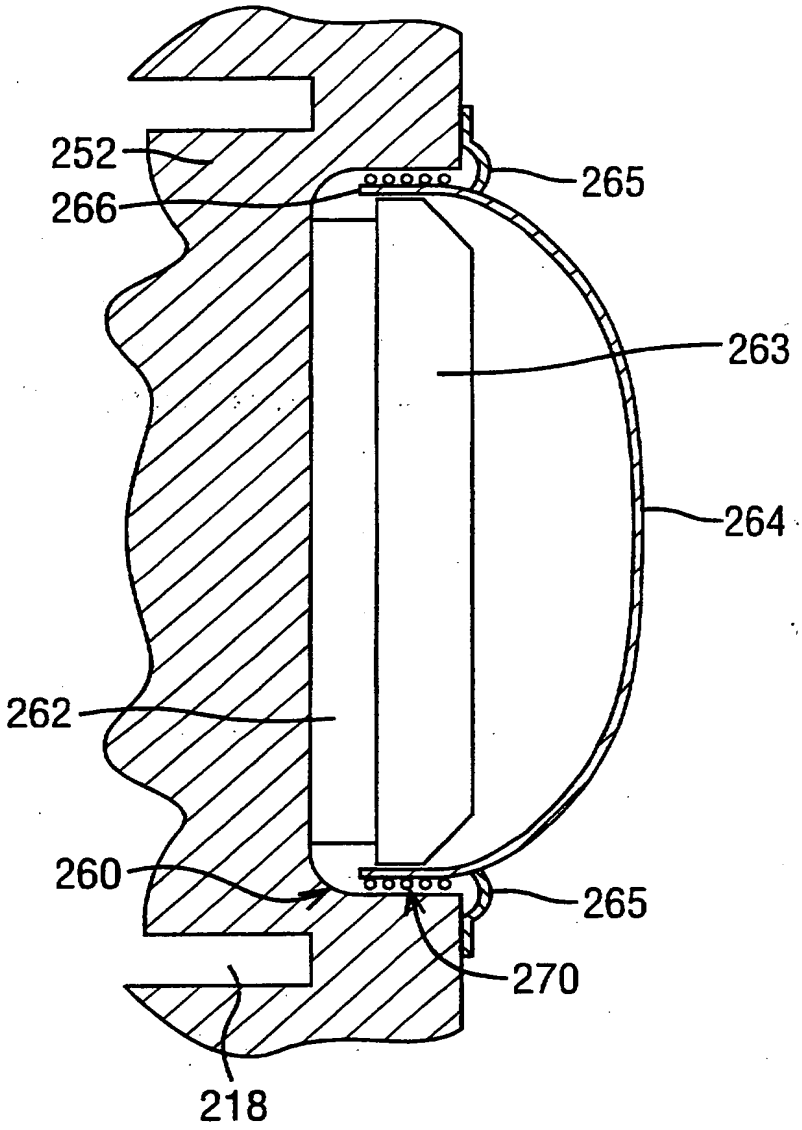


FIG. 5

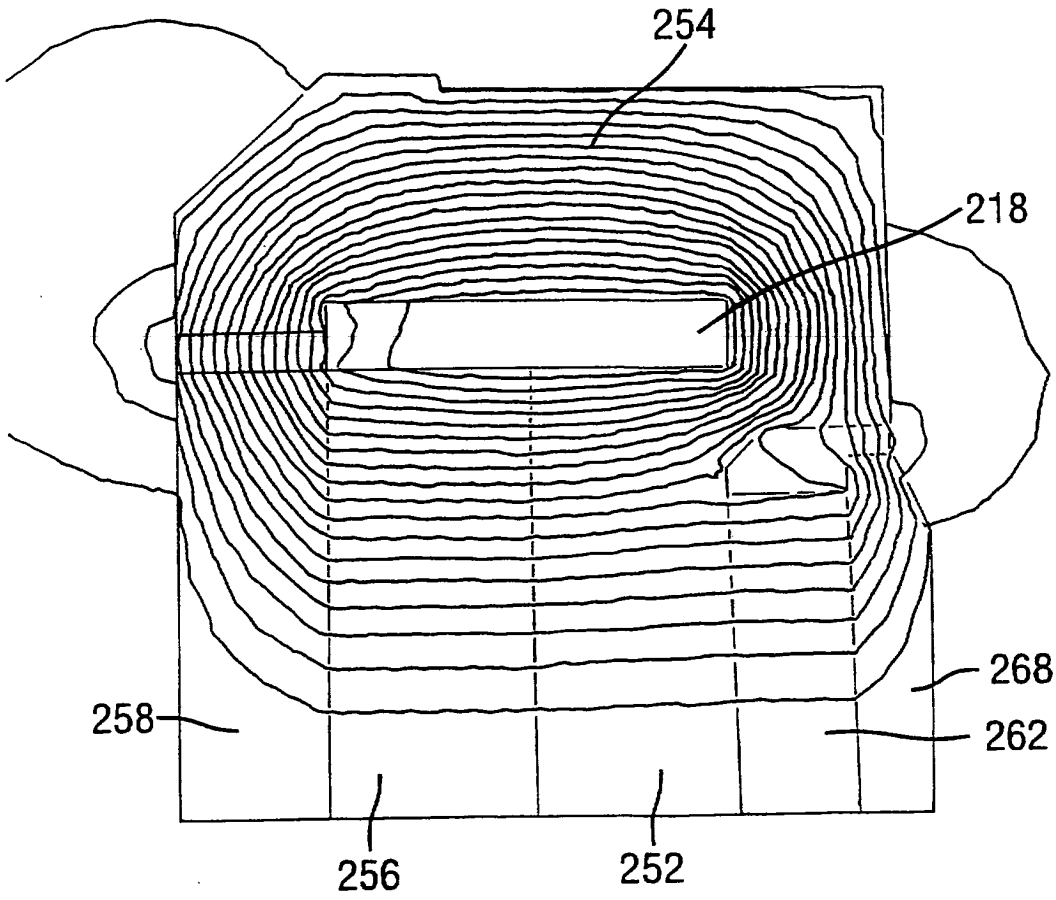


FIG. 6

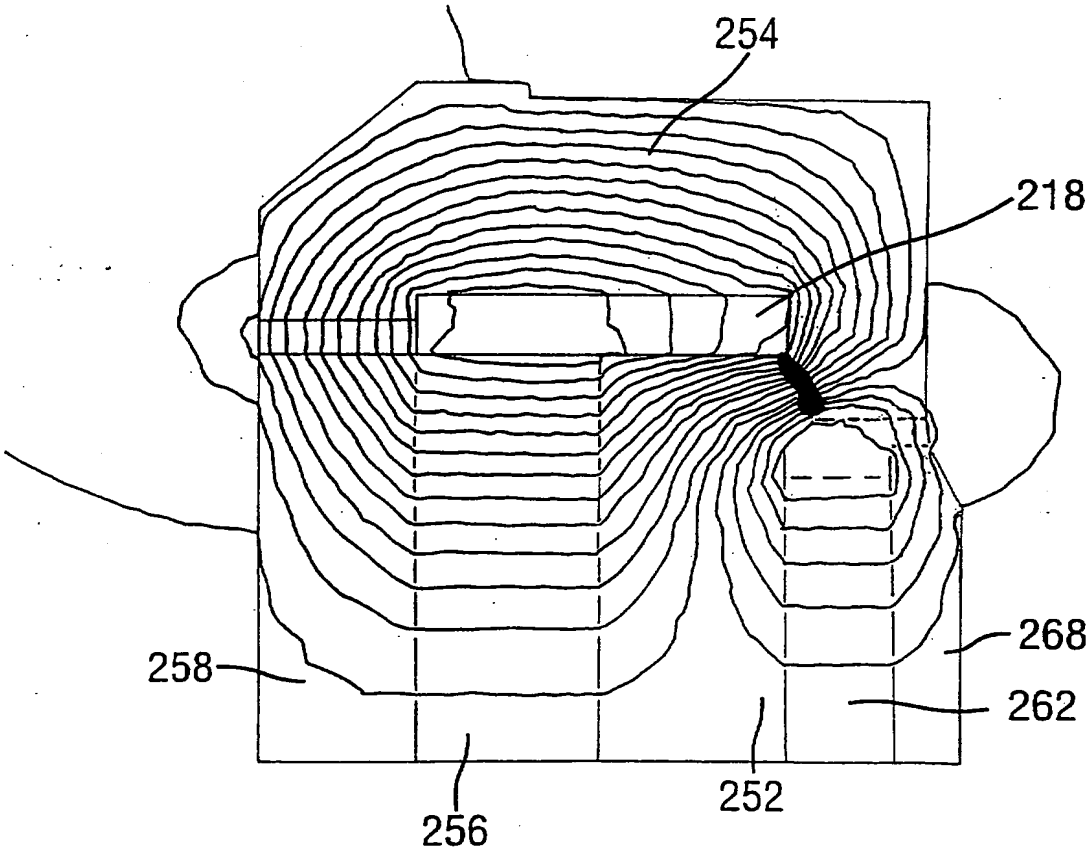
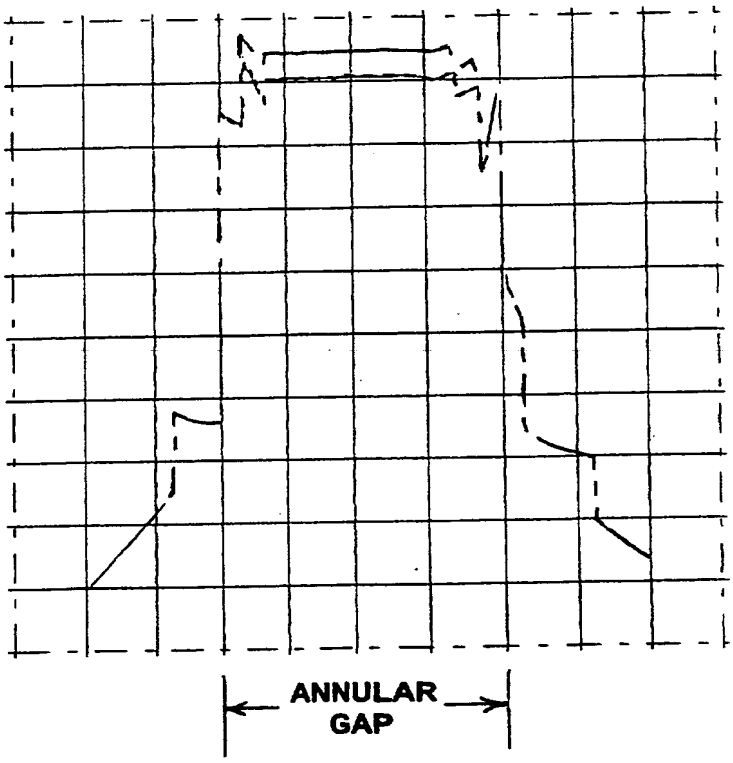


FIG. 7


RELATIVE MAGNETIC FLUX STRENGTH
ANNULAR GAP
RADIAL DIRECTION ON MAGNET ASSEMBLY OF SECOND FORM OF SPEAKER
MAGNETIC FIELDS ALIGNED
MAGNETIC FIELDS NOT ALIGNED

COAXIAL SPEAKER

This invention relates to a speaker incorporating both bass and tweeter structures, and can provide a thin speaker in which both the bass and tweeter structures are located within the outline of the speaker cone.

Speakers incorporating both bass and tweeter structures are known. For instance, U.K. Patent No. 2,300,783 (Harman International Industries Limited) relates to a modular tweeter fitted within a speaker such that a conductive dome skirt of the tweeter is inductively coupled to the voice coil of the speaker. Because the magnetic structure of the speaker in the Harman patent is mounted on the outside back of the support frame, the speaker is not very suitable for applications that require a speaker of shallow depth, for instance, speakers that are to be mounted within automobile doors. It would therefore be an advantage over the speaker of the Harman patent to have a speaker in which the magnetic structure and tweeter were both mounted so as to generally fit within the frustoconical volume defined by the cone of the speaker.

The subject invention may be described as a coaxial speaker that includes a bass cone radiator that defines a forward-facing concave region. A bass coil former with a bass coil thereon extends forwardly from the centre of the bass cone into the concave region. A magnetic structure is disposed in the concave region and defines a magnetic gap wherein the bass coil is received. A tweeter radiator is disposed in the concave region and received in a magnetic gap in the magnetic structure. By forward-facing is meant the direction in which the speaker is intended to radiate sound when installed.

In one form of the invention, the tweeter radiator is preferably disposed behind the magnetic structure, with the magnetic structure having an aperture through which, in operation, sound from the tweeter radiator passes. In such construction, the tweeter radiator is preferably received in the same magnetic gap as the bass coil, and even more pre-

ferably, is inductively coupled to the bass coil. Also preferably, the tweeter radiator has a forward-facing concave surface. A phase plug is preferably disposed in the aperture to horn-load the tweeter.

In another form of the invention, the magnetic gap in which the tweeter radiator is received faces forwardly, and the magnetic gap in which the bass coil is received faces rearwardly. The tweeter magnetic gap is preferably defined by a recess in the magnetic structure into which a tweeter magnet is received. Preferably the poles of the tweeter magnet are aligned with opposite poles of a magnet providing a magnetic field in the magnetic gap in which the bass coil is received.

The speaker preferably includes a webbed structural member adapted to be mounted by its periphery to a surrounding mounting structure, the structural member after such mounting presenting in a forward direction a generally planar face with the surrounding mounting structure. The magnetic structure is positioned centrally on the structural member. The structural member has apertures in an aperture zone between its periphery and the magnetic structure, the magnetic structure extending in a backward direction from the structural member and having a backward-facing annular gap. The bass cone has its outer periphery supported by the outer periphery of the structural member, and has its inner periphery connected to the bass coil former, the bass coil former and the bass coil extending into the annular gap. The tweeter structure is mounted on the magnetic structure.

The magnetic structure in the one form of the invention preferably has an axial bore therethrough, and the tweeter speaker structure includes a webbed tweeter structural member mounted at a back end of the axial bore, and also includes a tweeter cone having its inner periphery abutting an extension of the tweeter structural member, and having its outer periphery secured to a cylindrical tweeter skirt, the tweeter skirt extending into the annular gap and being inductively-coupled with the bass coil.

The magnetic structure in the other form of the invention has a central recess into which the tweeter speaker structure is fitted, the tweeter speaker structure having a forward-facing annular gap in which are retained a tweeter coil former and a tweeter coil, a dome-shaped tweeter cone having its periphery attached to the tweeter coil former. In this form of the invention, the magnetic structure and the tweeter speaker structure may each include a magnet, those magnets being oriented such that their magnetic fields are mutually attractive.

In either form of the invention, the speaker preferably also includes a back frame and an annular flexible suspension member. The back frame has its periphery connected to the periphery of the webbed structural member so as to enclose the magnetic structure and the cone therebetween. The suspension member extends from the back frame to the bass coil former to provide support for the bass coil former. The webbed structural member may have a series of radially-extending ribs in the aperture zone.

Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view through one type of conventional speaker, having a bass coil and tweeter skirt inductively-coupled within a magnetic structure, the magnetic structure being mounted behind a backplane of the speaker cone;

Figure 2 is a sectional view through a first embodiment of the speaker of the invention;

Figure 3 is a sectional view through a second embodiment of the speaker of the invention;

Figure 4 is an enlarged view of the tweeter portion of the second embodiment of the speaker of the invention;

Figure 5 is a flux plot of the magnetic field extending between two magnets with a first relative magnetic orientation, in the second embodiment of the speaker;

Figure 6 is a flux plot of the magnetic field extending

between two magnets with a second relative magnetic orientation, in the second embodiment of the speaker; and,

Figure 7 is a comparative plot of the magnetic flux in the cylindrical gap of the magnetic structure for the first and second relative magnetic orientations of the two magnets in the second embodiment of the speaker.

The conventional speaker illustrated in the sectional view of Figure 1 is the speaker disclosed in U.K. Patent 2,300,783, mentioned above. The magnetic structure, generally designated by the number 52, is mounted on a frame member 70 and extends behind the speaker cone 66. A tweeter structure, generally designated 10, has a dome support member 80 that is secured to an outer end of a cylindrical pole 60. A conductive skirted dome 82 extends over the dome support member 80, and has an integral cylindrical conductive skirt 84 that extends into an annular gap 62 and is inductively-coupled to a coil 72. The high-frequency (above about 4KHz) component of current passing through the coil 72 causes a reciprocatory motion in a conductive skirt 84, resulting in tweeter assembly 10 producing high-frequency sound to complement the lower-frequency sounds created by movement of the speaker cone 66.

Figure 2 illustrates a first form of the speaker of the invention. The speaker 100 has a frustoconically-shaped frame 102, across the larger end of which is mounted a generally-planar webbed plate 104. Centrally mounted on plate 104 is a magnetic structure generally designated 106. The magnetic structure 106 has a yoke 108 whose annular forward end extends approximately flush with a front face of the plate 104. The yoke 108 has a generally U-shaped radial cross-section, with an inner cylinder 110 and shorter outer cylinder 112 extending concentrically. A magnetic ring 114 is secured to the outer cylinder 112, and an annular plate 116 is secured to the magnetic ring 114. An annular gap 118 is defined by an outer face of the inner cylinder 110, and an inner face of magnetic ring 114 and annular plate 116. A cone 120 has its outer perimeter secured via a roll section 121 to the outer perimeter of the frame 102, and has its inner perimeter secured

to one end of a cylindrical coil former 122. The other end of the coil former 122 extends into the annular gap 118. A flexible corrugated suspension member 124 extends between the frame 102 and the other end of coil former 122. A coil 126 is mounted around the outside of the other end of coil former 122, the coil being positioned between the inner face of annular plate 116 and the outer face of the inner cylinder 110. A protective cover 128 extends across the one end of coil former 122 to prevent foreign material such as dust from entering into the annular gap 118. Since the back of frame 102 has a large circular opening 130, reciprocatory movement of the one end of coil former 122 is not impeded. Movement of coil former 122 results in the cone 120 producing sound waves that travel through apertures in the plate 104.

A tweeter speaker structure is mounted on the outer end of the inner cylinder 110. As illustrated in Figure 2, the tweeter speaker structure consists of a dome-shaped support member 132 having an outer portion resting on the outer end of cylinder 110, and an inner portion secured to the outer portion by a series of radial ribs 134. A conductive dome 136 extends over the dome-shaped support member 132 and has an integral conductive skirt 138. The skirt 138 extends into an annular gap between the other end of coil former 122 and the outer face of inner cylinder 110. A stem of a cap 140 extends through a central opening in the conductive dome 136, and is secured to the inner portion of dome-shaped support member 132. The cap 140 acts to retain conductive dome 136 in position on dome-shaped support member 132. Passing alternating current through the coil 126 results in vibration of annular cone 120, and also results, through inductive-coupling, in vibration of conductive dome 136. Vibration of conductive dome 136 causes sound waves to pass through the spaces between the radial ribs 134, and then through an axial bore 142 in magnetic structure 106. Thus, high-frequency (above about 4 KHz) sound leaves through a central region of the front of the speaker 100, and sound of lower frequency leaves through an annular surrounding region.

Figure 3 illustrates a second form of the speaker of the invention. As in the first form of the speaker, a generally-frustoconical frame 202 has a generally-planar webbed plate 204 extending across its larger end. The second form of the speaker also has a cone 220 connected to one end of a coil former 222, and has the other end of coil former 222 extending into an annular gap 218 as a pole piece. Also similar to the first form of the speaker, a coil 226 is mounted on the other end of coil former 222 and extends within the gap 218, and a protective dome 228 extends across the one end of coil former 222 to prevent foreign material entering the gap 218. Unlike in the first form of the speaker, however, the magnet assembly 250 does not have an axial bore similar to the axial bore 142. Instead, as shown in Figure 3, the magnetic structure 250 has a cylindrical body consisting of an inner solid cylindrical yoke 252 integrally connected to a surrounding cylinder 254. The cylindrical yoke 252 has a circular magnet 256 mounted on its circular end face. A circular plate 258 is mounted on the other side of circular magnet 256.

In this second form of the speaker, as shown in Figures 3 and 4, the tweeter speaker structure is not inductively-coupled to the voice coil 226, but is instead mounted in a cylindrical central recess 260 in a front end of the cylindrical yoke 252. A circular magnet 262 is centrally fitted into the recess 260, and covered by a circular plate 263. A dome 264 is supported by means of a surrounding annular suspension 265 that is mounted to the yoke 252. A former 266 is mounted on the periphery of the dome 264 and carries a tweeter voice coil 270. The voice coil 270 is held in the middle of the circular gap created by yoke 252 and circular plate 263. As shown in Figure 4, the tweeter voice coil 270 is mounted to the outside of the former 266. The coil 226 and the tweeter coil 270 are individually driven, and there is no inductive-coupling as in the first form of the speaker. However, as in the first form of the speaker, high-frequency sound leaves the front of the speaker through a central region, and lower-frequency sound leaves the front of the speaker through a

surrounding annular region.

It has been found that the relative orientation of the magnets 256 and 262 has an effect on the flux levels in the annular gaps housing the coil 226 and the tweeter coil 270. If the magnets are aligned, i.e. a north pole of magnet 256 faces a south pole of magnet 262, the flux lines are smooth as shown in Figure 5. In this case, the flux lines passing through coils 226 and 270 are stable and continuous. On the other hand, if one of the magnets is rotated such that the magnets have the same poles facing, the flux pattern is disrupted (Figure 6). Measurements have shown that the magnetic flux experienced by the coils 226 and 270 is more than 5% less for the disruptive pattern that for the smooth pattern. This difference is shown in Figure 7 in which the relative strength of the magnetic flux in annular gap 218 for the disruptive pattern is approximately 0.90/0.95 (measured in Tesla) that for the smooth pattern; an even larger difference was measured for the tweeter annular gap. Since higher and smoother flux patterns in the annular gaps of the coil 226 and tweeter coil 270 result in better sound, magnets 256 and 262 in the second form of the speaker are preferably inserted into the speaker so as to be aligned.

While the present invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation, and that changes may be made to the invention without departing from its scope as defined by the appended claims.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The text of the abstract filed herewith is repeated here as part of the specification.

An inverted coaxial speaker for use in automobile doors and similar thin structures has both its bass and tweeter components essentially located within the frustoconical out-

line of the bass speaker cone. A generally planar webbed structural member extends across the larger end of the speaker cone, and centrally supports a magnetic structure housing a coil for driving the speaker cone. A tweeter structure is mounted on the magnetic structure and takes one of two forms. In a first form of the speaker, the magnetic structure has an axial channel and the tweeter structure is mounted at the rear of the channel and sends sound through the channel; the tweeter has a conductive skirt that is inductively coupled to the coil. In a second form of the speaker, the magnetic structure has no axial channel but does have a frontal depression into which the tweeter structure is fitted; the tweeter structure has a tweeter voice coil instead of being inductively-coupled. In both forms of the speaker, sound above about 4KHz leaves from a central region of the webbed structural member, and lower-frequency sound leaves from an annular region surrounding the central region.

CLAIMS:

1. A coaxial speaker comprising a bass cone radiator defining a forward-facing (as herein defined) concave region, a bass coil former with a bass coil thereon extending forwardly from the centre of the bass cone into the concave region thereof, a magnetic structure disposed in the concave region and defining a magnetic gap wherein the bass coil is received, and a tweeter radiator disposed in the concave region and received in a magnetic gap in the magnetic structure.

2. A speaker as in claim 1, wherein the tweeter radiator is disposed behind the magnetic structure, the magnetic structure having an aperture through which in operation sound from the tweeter radiator passes.

3. A speaker as in claim 2, wherein the tweeter radiator is received in the same magnetic gap as the bass coil.

4. A speaker as in claim 3, wherein the tweeter radiator is inductively coupled to the bass coil.

5. A speaker as in claim 2, 3 or 4, wherein the tweeter radiator has a forward-facing concave surface.

6. A speaker as in any one of claims 2 to 5, wherein a phase plug is disposed in the aperture to horn-load the tweeter.

7. A speaker as in claim 1, wherein the magnetic gap in which the tweeter radiator is received faces forwardly, the magnetic gap in which the bass coil is received facing rearwardly.

8. A speaker as in claim 7, wherein the tweeter mag-

netic gap is defined by a recess in the magnetic structure into which a tweeter magnet is received.

9. A speaker as in claim 8, wherein the poles of the tweeter magnet are respectively aligned with opposite poles of a magnet providing a magnetic field in the magnetic gap in which the bass coil is received.

10. A speaker as in claim 1, comprising:

a webbed structural member adapted to be mounted by its periphery to a surrounding mounting structure, the structural member after such mounting presenting in a forward direction a generally planar face with the surrounding mounting structure;

the magnetic structure being positioned centrally on the structural member, the structural member having apertures in an aperture zone between its periphery and the magnetic structure, the magnetic structure extending in a backward direction from the structural member and having a backward-facing annular gap;

the bass cone having its outer periphery supported by the outer periphery of the structural member, and having its inner periphery connected to the bass coil former, the bass coil former and the bass coil extending into the annular gap; and,

the tweeter radiator being mounted on the magnetic structure.

11. A speaker as in claim 10, wherein the magnetic structure has an axial bore therethrough, and wherein the tweeter speaker structure comprises:

a webbed tweeter structural member mounted at a back end of the axial bore; and,

a tweeter cone having its inner periphery abutting an extension of the tweeter structural member, and having its outer periphery secured to a cylindrical tweeter skirt, the tweeter skirt extending into the annular gap and being inductively-coupled with the bass coil.

12. A speaker as in claim 10, wherein a forward-facing side of the magnetic structure has a central recess into which the tweeter speaker structure is fitted, the tweeter speaker structure having a forward-facing annular gap in which are retained a tweeter coil former and a tweeter coil, and wherein a dome-shaped tweeter cone has its periphery attached to the tweeter coil former.

13. A speaker as in claim 12, wherein the magnetic structure and the tweeter speaker structure each includes a magnet, those magnets being oriented such that their magnetic fields are mutually attractive.

14. A speaker as in any one of claims 10 to 13, wherein the speaker also comprises:

a back frame having its periphery connected to the periphery of the webbed structural member so as to enclose the magnetic structure and the cone therebetween; and,

an annular flexible suspension member extending from the back frame to the bass coil former to provide support for the bass coil former.

15. An speaker as in any one of claims 10 to 14, wherein the webbed structural member has a series of radially-extending ribs in the aperture zone.

16. A speaker substantially as herein described with reference to and as illustrated by Figures 2 to 7 of the drawings.

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Application No: GB 9929976.0 12 **Examiner:** Daniel Voisey
Claims searched: 1 to 16 **Date of search:** 23 July 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H4J (JAB, JCA)

Int Cl (Ed.7): H04R 1/24, 9/00, 9/02, 9/06

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 0665815 A	(MARCONI) see figure 2.	
A	EP 0624049 A2	(MATSUSHITA) see figure 9.	
X	US 5802191 A	(GUENTHER) see figures 7, 8 and 9 and column 2 line 53 to column 3 line 13 and column 5 lines 45 to 65.	1, 7, 8, 9

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.